AD-A132 139 GEOMETRIC AND PERFORMANCE CHARACTERISTICS OF COMMERCIAL CARGO SHIPS PART 1..(U) PRINCETON UNIV N J DEPT OF AEROSPACE AND MECHANICAL SCIENCES.. T E SWEENEY 1975 1/1

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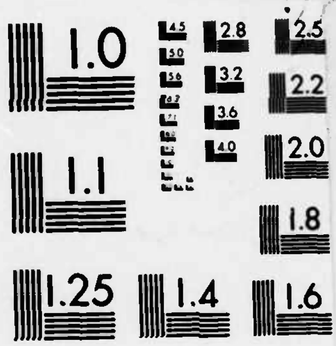

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Princeton University

GEOMETRIC AND PERFORMANCE CHARACTERISTICS

of

COMMERCIAL CARGO SHIPS

by

T. E. Sweeney

Part I*, Summer, 1975

AMS Report No. 1241

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Department of
Aerospace and
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* Covering the decades
1930 through 1950

FOREWORD

This paper, dealing with particular characteristics of commercial cargo ships of the 1930 - 1950 era, is but the first of a planned several part series of studies aimed at a preliminary evaluation of the potential of a sailing cargo ship.

To put the matter in better perspective the Flight Concepts Laboratory of Princeton University has, over the past decade or so, developed a rather unique sail of very high efficiency. It has been used (successfully) as wings for airplanes and as rotor blades for windmills. Its applicability as a sail for a cargo ship is, at this time, not yet determined - hence this study. It is quite probable that the reader will be either nautically or aeronautically orientated in his thinking, therefore, there may be some problem in the semantics of the matter, however, every effort is made to define the expressions of the two related disciplines as they occur in the text.

It should be kept in mind that the facts listed herein and the deductions made are but "homework" on the part of the author to establish a "first pass" as to the feasibility of the scheme of a partial reversion to the age of sail.

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INTRODUCTION

In order to determine the validity of the notion of re-applying sail power to an effective cargo ship on the basis of its competitiveness in the modern world the answers to many questions must be determined. Not least among these are:

1. What is the geometry of a currently acceptable commercial cargo ship?
2. What is the performance of a modern motor or steam cargo ship?

Of course, many other vital matters must be considered and they are planned to be studied in future papers - the two questions posed above, however, are undertaken to be answered here for the decades of the 30's, 40's and 1950's. Since many ships built during those years are still in active use the results of the study should shed considerable light on the subject. It is planned that a second group of ships - those built during the 1970's, 60's and overlapping back into the 50's will be similarly investigated in a following paper using as nearly as possible the techniques developed here.

DISCUSSION

The important geometric characteristics of the type ship under consideration are:

1. Length (L)
2. Beam (B)
3. Draft (d)
4. Depth (freeboard) (D)
5. Displacement
6. Fineness Ratio ($^L/B$)
7. Beam/draft ($^B/d$)
8. Depth/draft ($^D/d$)

By the careful selection of ships of a general type (not necessarily class) it appears not unreasonable that a geometric composite ship may be intellectually derived.

The performance characteristics necessary in order to make a first approximation of the load carrying capability and speed of such a composite ship are:

1. Dead wt. capacity (pay load)
2. Normal speed (cruise speed)
3. Speed length ratio ($V/L^{\frac{1}{2}}$)
4. Number of Propellers
5. Propeller efficiency (η_P)
6. Total Shaft Horsepower (100% power)
7. Normal Shaft Horsepower (@ 75% power)

8. Assumptions relative to wave drag

Tables 1 through 13 tabulate the geometry and performance of thirteen vessels built during the time period of present interest, therefore, most of the required information as outlined above may be gleaned from them. The resultant composite ship and its performance will be derived in both geometrical terms and in its load carrying capability, speed and thrust required.

In order to calculate the items of speed vs. thrust the total drag of the ship must be determined in non-dimensional terms. It is, therefore, of importance to make, at this point two vital assumptions:

1. The propeller efficiency of a single propeller ship may be as high as 0.80, however 0.75 has been assumed (Information Ref. 1).
2. The wave making drag of a ship with a speed-length ratio ($^V/L^{\frac{1}{2}}$) substantially less than 1.0 may be generally neglected. This is a convenience in this case that will not seriously impair the results.

It will be noted that among the characteristics listed on Tables 1 through 13 are the total installed shaft horsepower $(SHP)_T$ and the "normal" $(SHP)_N$. The value of $(SHP)_T$ was obtained from Reference 1 while $(SHP)_N$ was calculated on the basis of 75% power for the cruise condition. Thus:

$$(SHP)_N = (SHP)_T \ (.75) \text{ - } 1$$

Thrust horsepower must take into consideration the propeller efficiency which has been assumed as mentioned earlier to be 75%.

Therefore:

$$THP = (SHP)_N \eta_P = .75\ (SHP)_N \text{ - - - - - - - - - - - - } 2$$

and $THP = RV/550$

so $R = 550\ THP/_V = \dfrac{.75(SHP)_N\ (550)}{V}$

since $C_R = R/\frac{\rho}{2} V^2 Bd$

then $C_R = (550)(.75)(SHP)_N / \frac{\rho}{2} V^3 Bd \text{ ----} 3$

since $\rho = \gamma/g \cong 2\ ,\ \rho/2 \cong 1.0$

Therefore $C_R = (SHP)_N (412.5) / V^3 Bd \text{ ------} 4$

This then is the derivation of the expression for C_R which appears on each of the Tables 1 through 13 and upon which the actual value of the resistance coefficient has been calculated. It should be understood that these computed values of C_R include all forms of drag to which the ship is subjected.

Table 14 is a summary of the thirteen ships studied two of which (Liberty and Victory) were class type vessels. It will be noted that only nine of the thirteen ships studied are considered for the determination of the appropriate values of the composite cargo ship. The first three, the America, Queen Mary and the Bremen have been included in the study as a matter of interest but eliminated on the basis of tonnage and their speed length ratio. So also has the Quaker been eliminated because of her high value of speed-length ratio.

Averaging those values of ships of similar, but low values of $V/L^{\frac{1}{2}}$ (No.'s 4 through 12 of Table 14) yields the overall geometric and performance characteristics of a composite cargo ship. These appear in the last line of Table 14, and are again tabulated in Figure 1.

It is now possible to relate velocity in knots versus thrust required in pounds by means of the fundamental relationship:

$$R = C_R \frac{\rho}{2} V^2 Bd \quad \text{------------------} \quad 5$$

where: $\frac{\rho}{2} \cong 1.0$

$V = \text{ft./sec.}$

These calculations appear in Table 15.

These values of thrust (or resistance) in pounds versus velocity in knots are shown plotted in Figure 2, curve a. As discussed earlier thrust was determined by the assumed value of a propeller efficiency (η_p) of 75%, however, again from Reference 1 that value could be as low as 60% depending upon the fairing of the aft hull lines immediately forward of the propeller. From equations 2 and 4 it is apparent that the coefficient of resistance is a direct and linear function of propeller efficiency, therefore curve b of Figure 2, representing a propeller efficiency of 60%, has been constructed proportionally. It is reasonable to expect that the truth lies somewhere in the cross hatched area between the two curves - <u>if</u> the original assumption that "normal speed" is approximately 75% full power. It is not

reasonable (by aeronautical standards) that it would be higher, therefore, it is considered that the thrust required as shown in Figure 2 is conservatively high. This statement is based upon the reasoning that if normal speed related to a lower than 75% installed shaft horsepower then the coefficient of resistance and thus thrust required for a given speed would be lower.

It is alsmost irresistable not to proceed beyond this point and to show that a simple variation of the Princeton Sailwing can produce (without excessive sail area) the thrust necessary in a 20 kt. wind to easily compete with the powered vessel. This temptation, however, has been resisted simply because it is too early in the overall study to make a sufficiently strong case for the sailing vessel. Even so, it is admitted that preliminary calculations have been made which support the validity of sail power over other types of power for cargo vessels.

It is planned that a following paper will include a study of more modern cargo ships. Subsequent to that work a detailed analysis of the sails will be made. This will be intended to relate sail area; type of sail; sail setting relative to course, ship and wind; sail control and the arrangement of the sails for the various points of sailing.

CONCLUDING REMARKS

This has been but a preliminary study intended only as a beginning of an organized thought process to ultimately determine the validity of the notion of once again powering ocean going vessels by sail.

The paper will have only limited distribution - to selected persons for critical review of the work and to, hopefully, make helpful suggestions for the next phase. The reader is asked to be tolerant of this rather schoolboyish approach to what will become a complex problem. It is justified on the basis that one must start at the very beginning in an alien field.

REFERENCE

1. Lionel S. Marks, Mechanical Engineers Handbook, Fifth Edition, McGraw-Hill Book Company.

CARGO SHIP STATISTICS

TABLE 1

Item			
1.	Name of Vessel	AMERICA	
2.	W.L. Length (L)	690	ft.
3.	Beam (B)	93.5	ft.
4.	Depth (D)	55.5	ft.
5.	Draft (d)	32.5	ft.
6.	Displacement	35,440	Tons
7.	Dead Wt. Capacity	14,330	Tons
8.	Block Coefficient	0.59	
9.	Normal Speed	22	Kts.
10.	$V/L^{1/2}$	0.84	
11.	Propellers (No.)	2	
12.	Propeller RPM	128	
13.	Total Shp.	34,000	
14.	Normal Shp. (@ .75 total Shp.)	25,500	
15.	Engine Type:	Steam	
16.	Admiralty Coeff.	-	
17.	Machinery Wt. ($^{lbs.}$/Shp.)	-	
18.	Fineness Ratio ($^{L}/B$)	7.38	
19.	Beam/draft ($^{B}/d$)	2.88	
20.	Depth/draft ($^{D}/d$)	1.71	

$$C_R = \frac{SHP_N\,(412.5)}{V^3\ B\,d}$$

SHP_N	$V_{K\,N.}$	$V_{FPS.N}$	B	d	$V^3_{FPS.}$	$\rho/2$	C_R
25,500	22	37.2	93.5	32.5	51479	= 1.0	.067

CARGO SHIP STATISTICS

TABLE 2

Item			
1.	Name of Vessel	QUEEN MARY	
2.	W.L. Length (L)	1004	ft.
3.	Beam (B)	118	ft.
4.	Depth (D)	92.5	ft.
5.	Draft (d)	38.8	ft.
6.	Displacement	77,400	Tons
7.	Dead Wt. Capacity	-	Tons
8.	Block Coefficient	0.59	
9.	Normal Speed	29	Kts.
10.	$V/L^{1/2}$	0.92	
11.	Propellers (No.)	4	
12.	Propeller RPM	180	
13.	Total Shp.	158,000	
14.	Normal Shp. (@ .75 total Shp.)	118,500	
15.	Engine Type:	Steam	
16.	Admiralty Coeff.	-	
17.	Machinery Wt. (lbs./Shp.)	-	
18.	Fineness Ratio (L/B)	8.51	
19.	Beam/draft (B/d)	3.04	
20.	Depth/draft (D/d)	2.38	

$$C_R = \frac{SHP_N (412.5)}{V^3 \; Bd}$$

SHP_N	$V_{KN.}$	$V_{FPS.N}$	B	d	$V^3_{FPS.}$	$\rho/2$	C_R
118,500	29	49	118	38.8	118,000	= 1.0	0.090

CARGO SHIP STATISTICS

TABLE 3

Item			
1.	Name of Vessel	BREMEN	
2.	W.L. Length (L)	900	ft.
3.	Beam (B)	102	ft.
4.	Depth (D)	79.4	ft.
5.	Draft (d)	33.9	ft.
6.	Displacement	54,750	Tons
7.	Dead Wt. Capacity	14,390	Tons
8.	Block Coefficient	0.625	
9.	Normal Speed	27	Kts.
10.	$V/L^{1/2}$	0.90	
11.	Propellers (No.)	4	
12.	Propeller RPM	182	
13.	Total Shp.	100,000	
14.	Normal Shp. (@ .75 total Shp.)	75,000	
15.	Engine Type:	Steam	
16.	Admiralty Coeff.	-	
17.	Machinery Wt. (lbs./Shp.)	-	
18.	Fineness Ratio (L/B)	8.82	
19.	Beam/draft (B/d)	3.01	
20.	Depth/draft (D/d)	2.34	

$$C_R = \frac{SHP_N\,(412.5)}{V^3\ Bd}$$

SHP_N	$V_{KN.}$	$V_{FPS.N}$	B	d	$V^3_{FPS.}$	$\rho/2$	C_R
75,000	27	45.6	102	33.9	94,819	= 1.0	.094

CARGO SHIP STATISTICS

TABLE 4

Item			
1.	Name of Vessel	BEAVERGLEN	
2.	W.L. Length (L)	481	ft.
3.	Beam (B)	64	ft.
4.	Depth (D)	42.7	ft.
5.	Draft (d)	29.6	ft.
6.	Displacement	-	Tons
7.	Dead Wt. Capacity	11,000	Tons
8.	Block Coefficient	-	
9.	Normal Speed	16	Kts.
10.	$V/L^{1/2}$	.073	
11.	Propellers (No.)	1	
12.	Propeller RPM	108	
13.	Total Shp.	9000	
14.	Normal Shp. (@ .75 total Shp.)	6750	
15.	Engine Type:	Steam	
16.	Admiralty Coeff.	347	
17.	Machinery Wt. (lbs./Shp.)	213 #/SHP	
18.	Fineness Ratio (L/B)	7.5	
19.	Beam/draft (B/d)	2.16	
20.	Depth/draft (D/d)	.44	

$$C_R = \frac{SHP_N\,(412.5)}{V^3\ B d}$$

SHP_N	$V_{K\,N}$	$V_{FPS\,N}$	B	d	V^3_{FPS}	$\rho/2$	C_R
6750	16	27	64	29.6	19683	= 1.0	.075

CARGO SHIP STATISTICS

TABLE 5

Item			
1.	Name of Vessel	VICTORY CLASS	
2.	W.L. Length (L)	445	ft.
3.	Beam (B)	63.0	ft.
4.	Depth (D)	38.0	ft.
5.	Draft (d)	28.5	ft.
6.	Displacement	15,200	Tons
7.	Dead Wt. Capacity	10,750	Tons
8.	Block Coefficient	0.67	
9.	Normal Speed	15.5	Kts.
10.	$V/L^{1/2}$	0.74	
11.	Propellers (No.)	1	
12.	Propeller RPM	100	
13.	Total Shp.	6000	
14.	Normal Shp. (@ .75 total Shp.)	4500	
15.	Engine Type:	Steam	
16.	Admiralty Coeff.	-	
17.	Machinery Wt. ($^{lbs.}$/Shp.)	-	
18.	Fineness Ratio ($^{L}/B$)	7.1	
19.	Beam/draft ($^{B}/d$)	2.21	
20.	Depth/draft ($^{D}/d$)	1.33	

$$C_R = \frac{SHP_N\,(412.5)}{V^3\; Bd}$$

SHP_N	$V_{K\,N.}$	$V_{FPS.N}$	B	d	$V^3_{FPS.}$	$\rho/2$	C_R
4500	15.5	26.2	63	28.5	17,987	= 1.0	.057

CARGO SHIP STATISTICS

TABLE 6

Item			
1.	Name of Vessel	RED JACKET	
2.	W.L. Length (L)	435	ft.
3.	Beam (B)	63	ft.
4.	Depth (D)	40.5	ft.
5.	Draft (d)	25.8	ft.
6.	Displacement	13,900	Tons
7.	Dead Wt. Capacity	7,620	Tons
8.	Block Coefficient	0.69	
9.	Normal Speed	15.5	Kts.
10.	$V/L^{1/2}$	0.75	
11.	Propellers (No.)	1	
12.	Propeller RPM	92	
13.	Total Shp.	6000	
14.	Normal Shp. (@ .75 total Shp.)	4500	
15.	Engine Type:	Steam	
16.	Admiralty Coeff.	448	
17.	Machinery Wt. ($^{lbs.}/Shp.$)	-	
18.	Fineness Ratio ($^L/B$)	6.9	
19.	Beam/draft ($^B/d$)	2.44	
20.	Depth/draft ($^D/d$)	1.57	

$$C_R = \frac{SHP_N\,(412.5)}{V^3\ B d}$$

SHP_N	$V_{K\,N.}$	$V_{FPS.\,N}$	B	d	$V^3_{FPS.}$	$\rho/2$	C_R
4500	15.5	26.2	63	25.8	17,987	= 1.0	.063

CARGO SHIP STATISTICS

TABLE 7

Item			
1.	Name of Vessel	AGWIMONTE	
2.	W.L. Length (L)	395	ft.
3.	Beam (B)	60	ft.
4.	Depth (D)	37.5	ft.
5.	Draft (d)	27.5	ft.
6.	Displacement	12,860	Tons
7.	Dead Wt. Capacity	9,100	Tons
8.	Block Coefficient	0.69	
9.	Normal Speed	14	Kts.
10.	$V/L^{1/2}$	0.70	
11.	Propellers (No.)	1	
12.	Propeller RPM	90	
13.	Total Shp.	4000	
14.	Normal Shp. (@ .75 total Shp.)	3000	
15.	Engine Type:	Steam	
16.	Admiralty Coeff.	-	
17.	Machinery Wt. ($^{lbs.}$/Shp.)	-	
18.	Fineness Ratio (^{L}/B)	6.58	
19.	Beam/draft (^{B}/d)	2.18	
20.	Depth/draft (^{D}/d)	1.36	

$$C_R = \frac{SHP_N (412.5)}{V^3\ Bd}$$

SHP_N	$V_{K\,N}$	$V_{FPS.N}$	B	d	$V^3_{FPS.N}$	$\rho/2$	C_R
3000	14	23.7	60	27.5	13,312	= 1.0	.056

CARGO SHIP STATISTICS

TABLE 8

Item			
1.	Name of Vessel	SEA FOX	
2.	W.L. Length (L)	473	ft.
3.	Beam (B)	69.5	ft.
4.	Depth (D)	42.5	ft.
5.	Draft (d)	27.3	ft.
6.	Displacement	17,600	Tons
7.	Dead Wt. Capacity	11,920	Tons
8.	Block Coefficient	-	
9.	Normal Speed	16.5	Kts.
10.	$V/L^{1/2}$	-	
11.	Propellers (No.)	1	
12.	Propeller RPM	85	
13.	Total Shp.	8500	
14.	Normal Shp. (@ .75 total Shp.)	6370	
15.	Engine Type:	Steam	
16.	Admiralty Coeff.	-	
17.	Machinery Wt. ($^{lbs.}$/Shp.)	-	
18.	Fineness Ratio ($^L/B$)	6.8	
19.	Beam/draft ($^B/d$)	2.55	
20.	Depth/draft ($^D/d$)	1.56	

$$C_R = \frac{SHP_N\,(412.5)}{V^3\;Bd}$$

SHP_N	$V_{K\,N.}$	$V_{FPS.N}$	B	d	$V^3_{FPS.}$	$\rho/2$	C_R
6370	16.5	27.9	69.5	27.3	21,718	= 1.0	0.064

CARGO SHIP STATISTICS

TABLE 9

Item			
1.	Name of Vessel	Black Falcon	
2.	W.L. Length (L)	390	ft.
3.	Beam (B)	54	ft.
4.	Depth (D)	32.0	ft.
5.	Draft (d)	24.3	ft.
6.	Displacement	11,200	Tons
7.	Dead Wt. Capacity	7,500	Tons
8.	Block Coefficient	.745	
9.	Normal Speed	13.2	Kts.
10.	$V/L^{1/2}$	0.67	
11.	Propellers (No.)	1	
12.	Propeller RPM	99.5	
13.	Total Shp.	2974	
14.	Normal Shp. (@ .75 total Shp.)	2230	
15.	Engine Type:	Steam	
16.	Admiralty Coeff.	-	
17.	Machinery Wt. (lbs./Shp.)	-	
18.	Fineness Ratio (L/B)	7.22	
19.	Beam/draft (B/d)	2.22	
20.	Depth/draft (D/d)	1.32	

$$C_R = \frac{SHP_N\,(412.5)}{V^3\;Bd}$$

SHP_N	$V_{KN.}$	$V_{FPS.N}$	B	d	$V^3_{FPS.^3}$	$\rho/2$	C_R
2230	13.2	22.3	54	24.3	11,090	= 1.0	.063

CARGO SHIP STATISTICS

TABLE 10

Item			
1.	Name of Vessel	ANGELINA	
2.	W.L. Length (L)	390	ft.
3.	Beam (B)	55	ft.
4.	Depth (D)	30.5	ft.
5.	Draft (d)	24.6	ft.
6.	Displacement	10,530	Tons
7.	Dead Wt. Capacity	7,250	Tons
8.	Block Coefficient	0.70	
9.	Normal Speed	13	Kts.
10.	$V/L^{1/2}$	0.66	
11.	Propellers (No.)	1	
12.	Propeller RPM	90	
13.	Total Shp.	3150	
14.	Normal Shp. (@ .75 total Shp.)	2363	
15.	Engine Type:	Steam	
16.	Admiralty Coeff.	-	
17.	Machinery Wt. (lbs./Shp.)	-	
18.	Fineness Ratio (L/B)	7.1	
19.	Beam/draft (B/d)	2.2	
20.	Depth/draft (D/d)	1.2	

$$C_R = \frac{SHP_N (412.5)}{V^3\ B d}$$

SHP_N	V_{K_N}	V_{FPS_N}	B	d	V^3_{FPS}	$\rho/2$	C_R
2363	13	22	55	24.6	10,648	= 1.0	.068

CARGO SHIP STATISTICS

TABLE 11

Item			
1.	Name of Vessel	LIBERTY CLASS	
2.	W.L. Length (L)	428	ft.
3.	Beam (B)	56.9	ft.
4.	Depth (D)	37.3	ft.
5.	Draft (d)	27.7	ft.
6.	Displacement	14,250	Tons
7.	Dead Wt. Capacity	10,844	Tons
8.	Block Coefficient	0.74	
9.	Normal Speed	11.5	Kts.
10.	$V/L^{1/2}$	0.56	
11.	Propellers (No.)	1	
12.	Propeller RPM	76	
13.	Total Shp.	2300	
14.	Normal Shp. (@ .75 total Shp.)	1725	
15.	Engine Type:	Steam	
16.	Admiralty Coeff.	-	
17.	Machinery Wt. (lbs./Shp.)	-	
18.	Fineness Ratio (L/B)	7.5	
19.	Beam/draft (B/d)	2.05	
20.	Depth/draft (D/d)	1.35	

$$C_R = \frac{SHP_N\,(412.5)}{V^3\ B d}$$

SHP_N	V_{K_N}	$V_{fps._N}$	B	d	$V^3_{fps.^3}$	$\rho/2$	C_R
1725	11.5	19.4	56.9	27.7	7,301	= 1.0	.062

CARGO SHIP STATISTICS

TABLE 12

Item			
1.	Name of Vessel	..RC WEAR	
2.	W.L. Length (L) - - - - - - - - - - - - - -	360	ft.
3.	Beam (B)- - - - - - - - - - - - - - - - -	57.5	ft
4.	Depth (D) - - - - - - - - - - - - - - - -	26.8	ft.
5.	Draft (d) - - - - - - - - - - - - - - - -	22.2	ft.
6.	Displacement - - - - - - - - - - - - - - -	9,060	Tons
7.	Dead Wt. Capacity - - - - - - - - - - - - -	7,000	Tons
8.	Block Coefficient - - - - - - - - - - - - -	0.70	
9.	Normal Speed - - - - - - - - - - - - - - -	12.1	Kts.
10.	$V/L^{1/2}$ - - - - - - - - - - - - - - - -	0.64	
11.	Propellers (No.) - - - - - - - - - - - - -	1	
12.	Propeller RPM - - - - - - - - - - - - - - -	72.5	
13.	Total Shp.- - - - - - - - - - - - - - - - -	1900	
14.	Normal Shp. (@ .75 total Shp.)- - - - -	1425	
15.	Engine Type:	Steam	
16.	Admiralty Coeff.- - - - - - - - - - - - -	430	
17.	Machinery Wt. ($^{lbs.}$/Shp.) - - - - - - -	-	
18.	Fineness Ratio (^{L}/B) - - - - - - - - - -	6.3	
19.	Beam/draft (^{B}/d) - - - - - - - - - - -	2.6	
20.	Depth/draft (^{D}/d) - - - - - - - - - - - -	1.21	

$$C_R = \frac{SHP_N\,(412.5)}{V^3\ B\,d}$$

SHP_N	$V_{K\,N.}$	$V_{FPS.N}$	B	d	$V^3_{FPS.}$	$\rho/2$	C_R
1425	12.1	20.5	57.5	22.2	8615	= 1.0	.053

CARGO SHIP STATISTICS

TABLE 13

Item			
1.	Name of Vessel	QUAKER	
2.	W.L. Length (L) - - - - - - - - - - - - - - -	280	ft.
3.	Beam (B)- - - - - - - - - - - - - - - - - -	48.5	ft.
4.	Depth (D) - - - - - - - - - - - - - - - - -	32.2	ft.
5.	Draft (d) - - - - - - - - - - - - - - - - -	18.5	ft.
6.	Displacement - - - - - - - - - - - - - - -	4215	Tons
7.	Dead Wt. Capacity - - - - - - - - - - - - -	2050	Tons
8.	Block Coefficient - - - - - - - - - - - - -	0.585	
9.	Normal Speed - - - - - - - - - - - - - - -	16.5	Kts.
10.	$V/L^{1/2}$ - - - - - - - - - - - - - - - - -	0.99	
11.	Propellers (No.) - - - - - - - - - - - - -	1	
12.	Propeller RPM - - - - - - - - - - - - - - -	120	
13.	Total Shp.- - - - - - - - - - - - - - - - -	4000	
14.	Normal Shp. (@ .75 total Shp.)- - - - -	3000	
15.	Engine Type:	Steam	
16.	Admiralty Coeff.- - - - - - - - - - - - -	-	
17.	Machinery Wt. (lbs./Shp.) - - - - - - -	-	
18.	Fineness Ratio (L/B) - - - - - - - - - -	5.8	
19.	Beam/draft (B/d) - - - - - - - - - - - -	2.62	
20.	Depth/draft (D/d) - - - - - - - - - - - -	1.74	

$$C_R = \frac{SHP_N\,(412.5)}{V^3\,Bd}$$

SHP_N	$V_{K\,N.}$	$V_{FPS.\,N}$	B	d	$V^3_{FPS.}$ =	$\rho/2$	C_R
3000	16.5	27.9	48.5	18.5	21718	= 1.0	.063

From TABLE	NAME	TYPE	L, ft.	DISP. Tons	V Kts.	$V/L^{\frac{1}{2}}$	C_R	L/B	B ft.	d ft.
1	AMERICA	p - c	690	35,440	22.0	0.84	.067	7.38	93.5	32.5
2	QUEEN MARY	p - c	1004	77,400	29.0	0.92	.090	8.51	118	38.8
3	BREMEN	p - c	900	54,750	27.0	0.90	.094	8.82	102	33.9
4	BEAVERGLEN	c	481	15,500*	16.0	0.73	.075	7.50	64	29.6
5	VICTORY CLASS	c	445	15,200	15.5	0.74	.057	7.10	63	28.5
6	RED JACKET	c	435	13,900	15.5	0.75	.063	6.90	63	25.8
7	AGWIMONTE	c	395	12,860	14.0	0.70	.056	6.58	60	27.5
8	SEA FOX	c	473	17,600	16.5	0.76	.064	6.80	69.5	27.3
9	BLACK FALCON	c	390	11,200	13.2	0.67	.063	7.22	54	24.3
10	ANGELINA	c	390	10,530	13.0	0.66	.068	7.10	55	24.6
11	LIBERTY CLASS	c	428	14,250	11.5	0.56	.062	7.50	56.9	27.7
12	ARC WEAR	c	360	9,060	12.1	0.64	.053	6.30	57.5	22.2
13	QUAKER	c	280	4,215	16.5	0.99	.063	5.80	48.5	18.5
Av.	COMPOSITE	c	422	13,300	14.2	0.69	.062	7.0	60.3	26.4

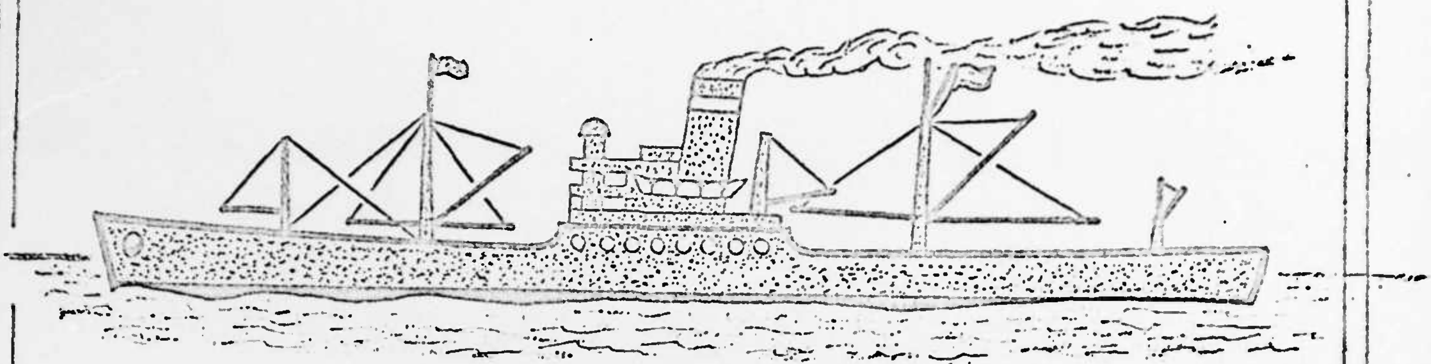
p - Passenger
c - Cargo

TABLE 14

TABLE 15

V KTS.	V FPS.	V^2 FPS^2	CR	B d av.	$T(R)_{lbs.}$
2	3.38	11.42	.062	1592	1,127
4	6.76	45.70			4,511
6	10.14	102.80			10,146
8	13.52	182.80			18,042
10	16.90	285.60			28,189
12	20.28	411.30			40,595
14	23.66	559.80			55,252
18	30.42	925.40			91,336
22	37.18	1382.60			136,462

FIG. 1



MAJOR DIMENSIONS AND PERFORMANCE CHARACTERISTICS OF THE COMPOSITE CARGO SHIP OF THE 1930's, 40's AND 50's

LENGTH	422 Ft.
BEAM	60.3 Ft.
DRAFT	26.4 Ft.
FINENESS RATIO	7.0
DISPLACEMENT	13,300 Tons
NORMAL SPEED	14.2 Kts.
SPEED/LENGTH RATIO	0.69

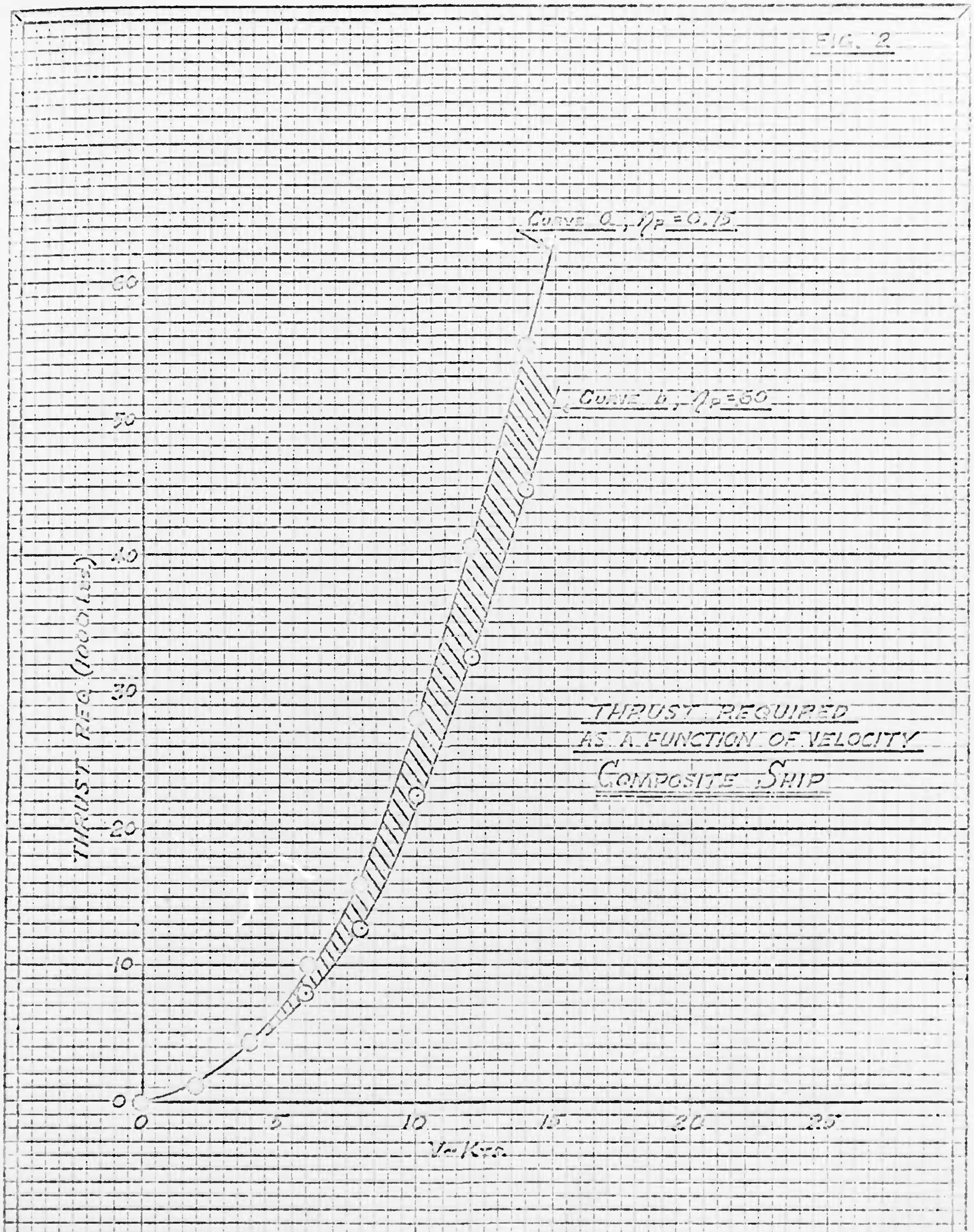


FIG. 2
Curve a, η_P = 0.75
Curve b, η_P = .60
THRUST REQUIRED
AS A FUNCTION OF VELOCITY
COMPOSITE SHIP
THRUST REQ (1000 LBS)
0
10
20
30
40
50
60
0
5
10
15
20
25
V - KTS.

END

FILMED

9-83

DTIC